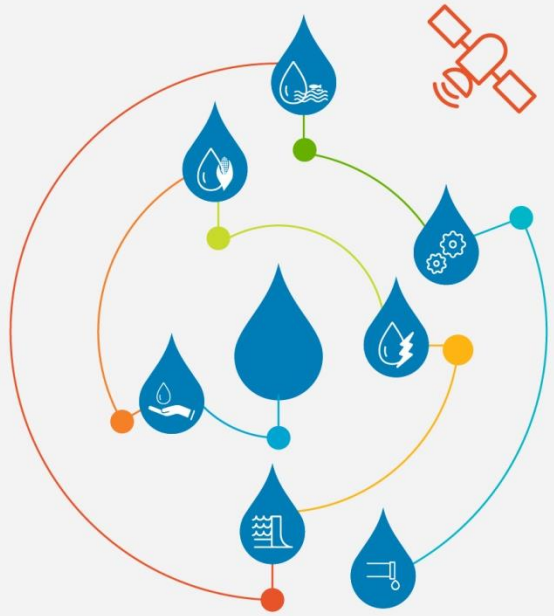
Where to invest in the Indus Basin Irrigation System in Pakistan to improve land and water productivity? Insights from a hierarchical model



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Background: Indus Basin Irrigation System

Source: Nisar Ahmad Khan (http://pakistangeographic.com)

- The basin covers the whole of Punjab and KPK, most of Sindh, and eastern part of Balochistan
- Provides water for 90% of the food production in Pakistan
- World's largest contiguous irrigation scheme
- Irrigates 35 million acres
- 107,000 watercourses stretching 1.6 million KM

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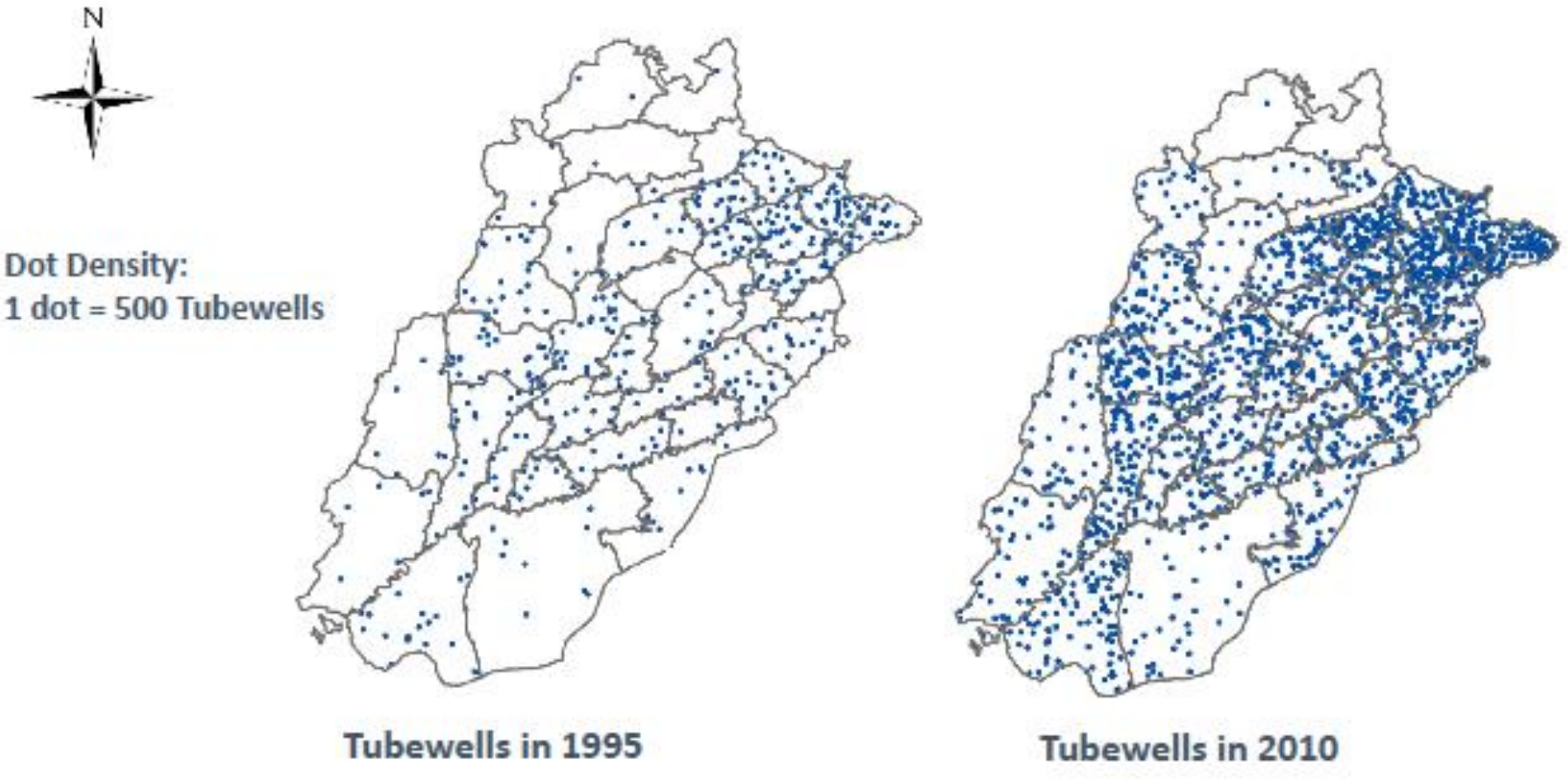
Challenges in irrigated agriculture in the IBIS

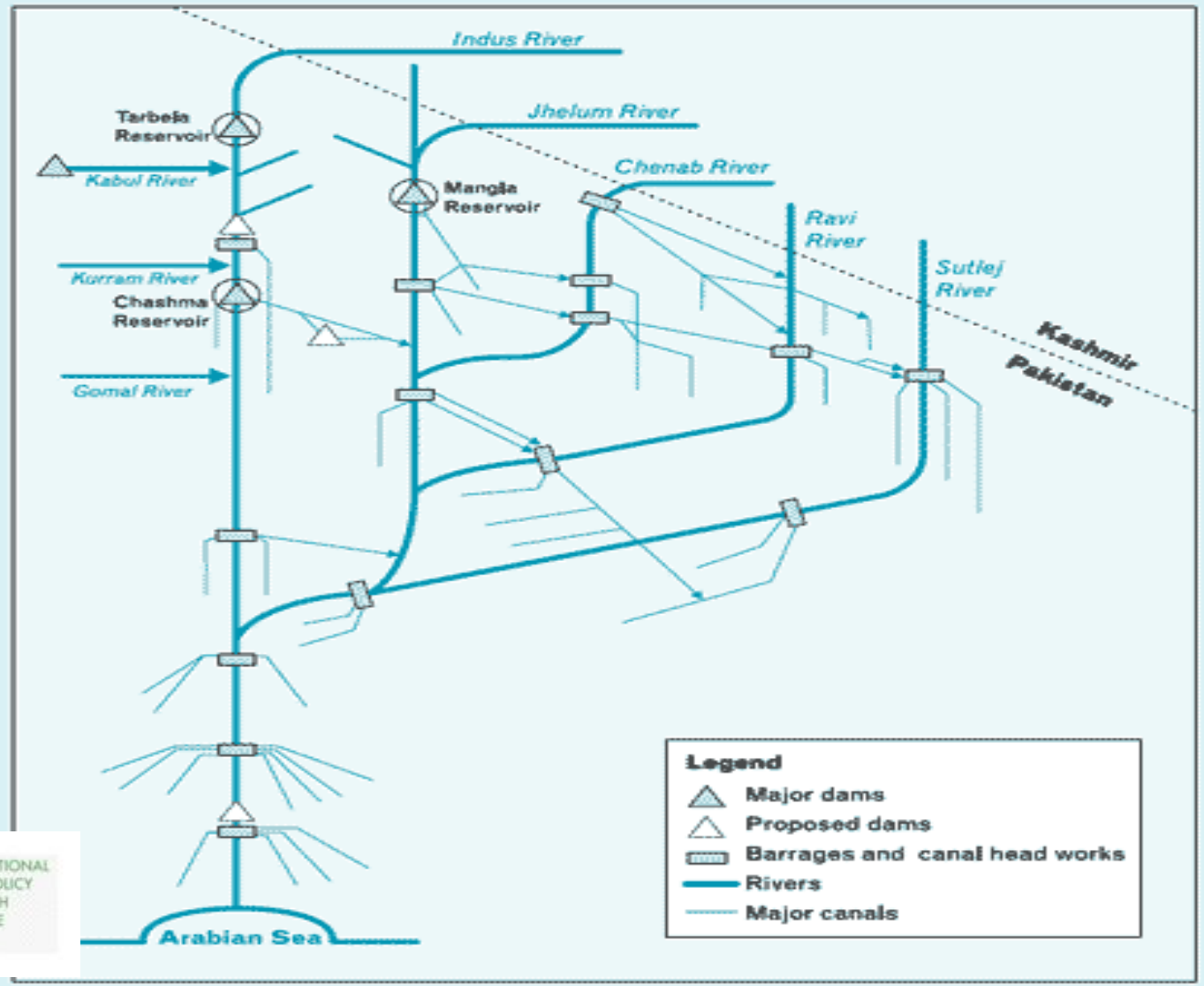
- Irrigated agriculture is challenged by water scarcity, salinity, waterlogging, and high conveyance losses
- Growing water shortages and increased variability in water flows
- 25% and 45% of the water that reaches the head of distributaries and watercourses is not directly available to farmers due to seepage & evaporation
- Water shortages have contributed to the over-utilization of groundwater resources, with implications for the already strained energy situation in the country and environmental concerns such as increased salinity

Increasing reliance on groundwater



Pumping density in Punjab (Siddiqi & Wescoat, 2013)

IBIS: a hierarchical canal operation by design



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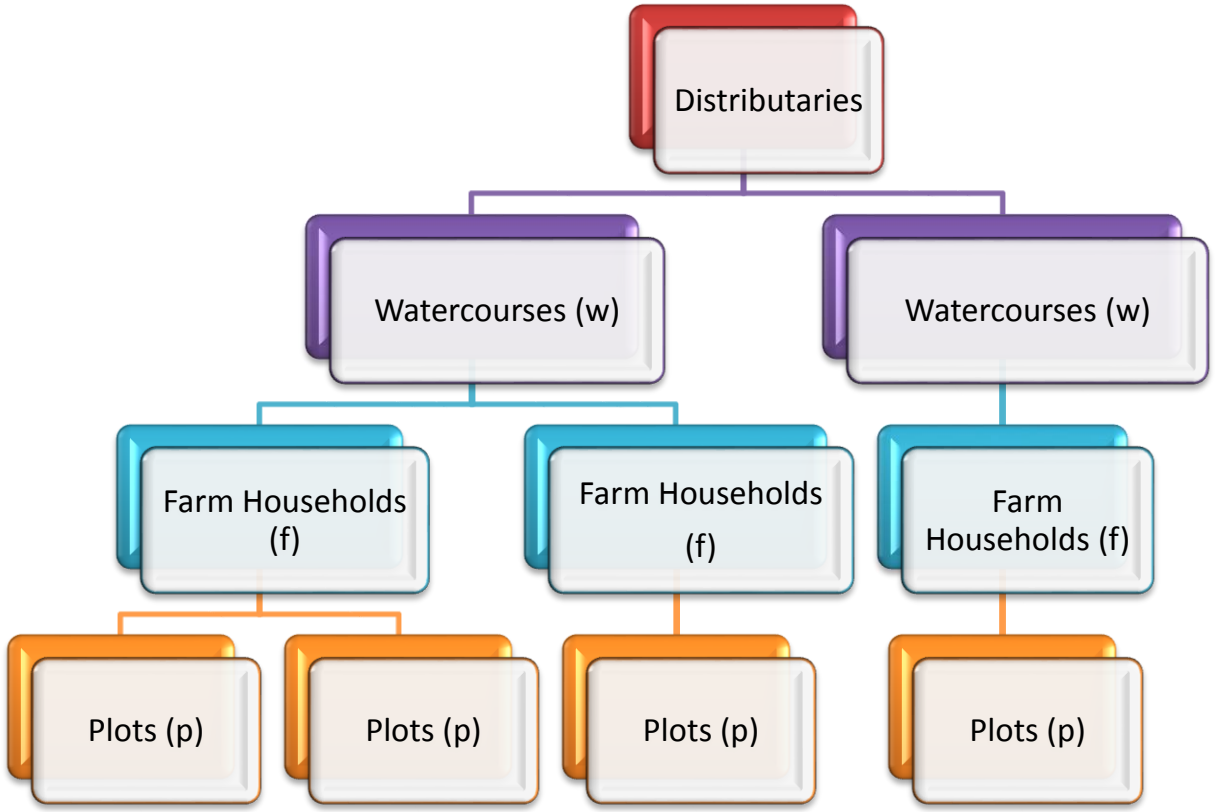
Objective

- Where to intervene in the system to improve system efficiency?
- We use multilevel modeling to explore the relative importance of plots, farms, watercourses, and distributaries on the levels and variance of wheat yield
- Identify entry points to improve agricultural water management in a way that can guide prioritization of investments across the different levels of the irrigation network.

Data

- Pakistan Rural Household Panel Survey
- Detailed plot level information with highly disaggregated data on irrigation types, methods, and institutions
- We focus on one crop (wheat) in the Rabi (winter) seasons of 2011-2012 and 2013-14
- Wheat is the major crop in Rabi (~3/4th of harvested land)
- The focus on Rabi and wheat allows us to abstract from crop selection issues in the more diversified Kharif season

Methodology



- To explore the relative importance of p, f, w, and d on agricultural productivity (y) and its variance
- We used a multilevel modeling where p are clustered into f, f are clustered into w, and w are clustered into d
- It identifies how much of the total yield variance that is unexplained by plot level characteristics can be explained at the level of f, w, and d

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Methodology cont'd

- Plot level explanatory variables include fertilizer, family and hired labor days, machinery hours, number of canal and groundwater irrigations, tenancy status, waterlogging and salinity conditions, soil fertility, soil type, slope, erosion problems, and use of manure

- We also used year and province dummy variables

Methodology cont'd

- Our sample has 47 groupings at the distributary level, 88 groupings at the watercourse level, and 408 observations at the household level, for a total of 719 plots.

- We present results from 3 specifications of hierarchies: (i) only the farm level (ii) both the farm and watercourse levels and (iii) farms, watercourses, and distributaries

Main Findings

- We find that out of the total variation in wheat yield that is not explained by plot specific characteristics, distributary, watercourse, and household level effects explain 13%, 5%, and 59% of the variation
- The size of total land owned explains much of the household level variation
- Compared to watercourses, investments that improve irrigation water delivery at the distributary level provide larger impact per unit of dollar invested in terms of reducing yield gaps among farmers
- Such information, if coupled with information on relative investment costs per hectare of improved irrigation, can better guide prioritization of investments in the IBIS

Other Findings

- The major determinants of wheat yield are frequency of canal irrigation, use of hired labor and threshers, tenancy status, and size of land ownership.
- A 1%-increase in the # of canal irrigation leads to a 0.05% increase in yield
- A 1%-increase in hired labor hours leads to a 0.02% increase in yield.
- A 1%-increase in thresher use leads to a 0.06% increase in yield.
- Yield is 10% higher in shared-in plots than on own plots.
- A 1%-increase in the amount of land owned leads to a 0.89% increase in yield.

Thank You

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